Conceptual Models for NPS I&M Networks

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Pacific West Region Meeting

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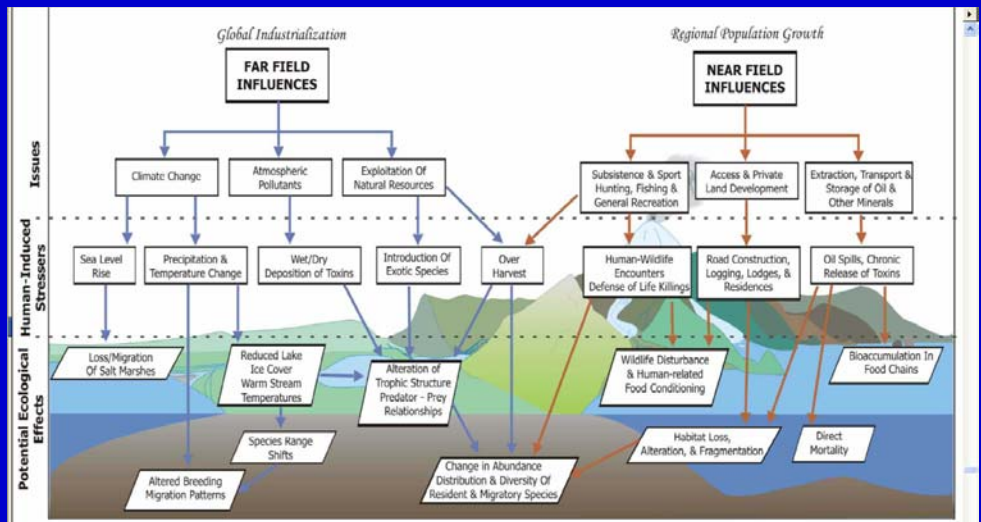


Figure 2-9. . Human Activities Model. Far-field and near-field issues that act as stressors to affect ecosystems in the Southwest Alaska Network. Far-field human-related issues are manifested as climate change, long-distance air pollution, depletion of migratory species, and introduction of exotic species. . Near-field human-related issues are manifested as harvest of plants and animals, recreational use, private lands development, and the extraction, storage, and transport of oil, gas, and mineral resources in Bristol Bay and the Northern Gulf of Alaska.

Two views of conceptual models:

- central element of monitoring plan and program
  - organized and communicated complex info on system dynamics
  - improved understanding
  - great for justifying vital signs (will be good for interpretation)

- a real struggle – another WASO requirement
  - an almost complete waste of time
  - “our oversight committees hate them”
  - a duplication of the obvious

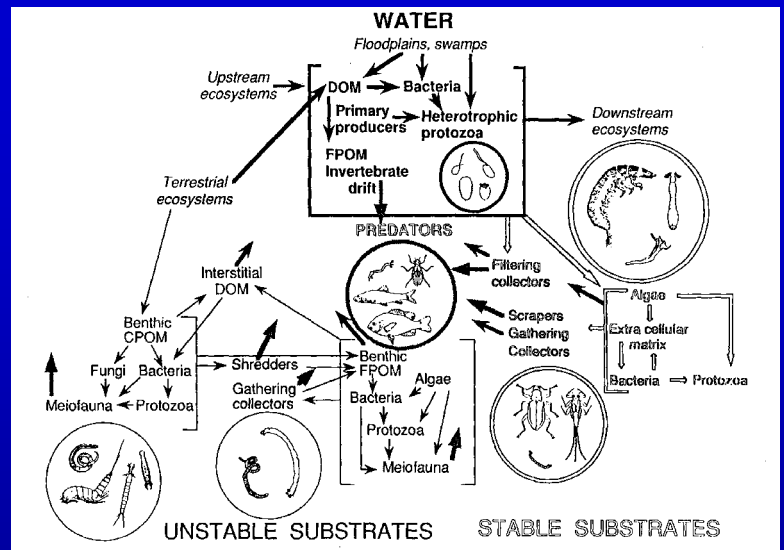


Figure 3. A conceptual model of the food web of a southeastern blackwater river as a mosaic of food webs characteristic of geomorphically defined habitats linked by flowing water. Sketches indicate consumers representative of each food web in a southeastern blackwater river. Each habitat is denoted with a different typeface and arrow: water (bold), unstable substrates (medium), and stable substrates (outline). Gray arrows denote consumption by predators, and bold arrows indicate movement into the water. Outside sources of organic matter are indicated in italics.

Roadmap

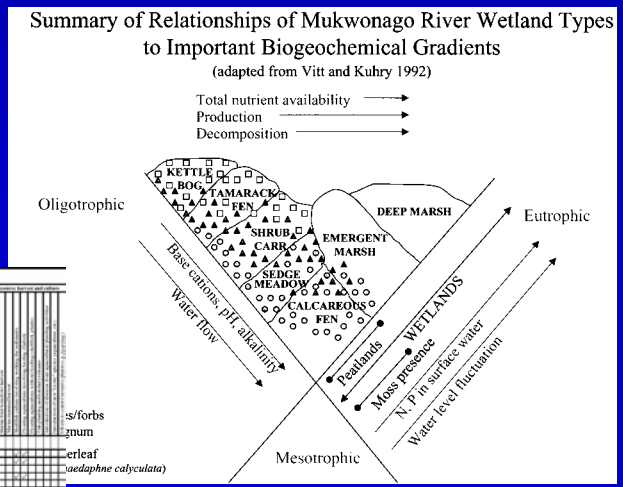
- Goals and observations from networks
- Examples, alternative models, etc
- Recommendations
- Resources

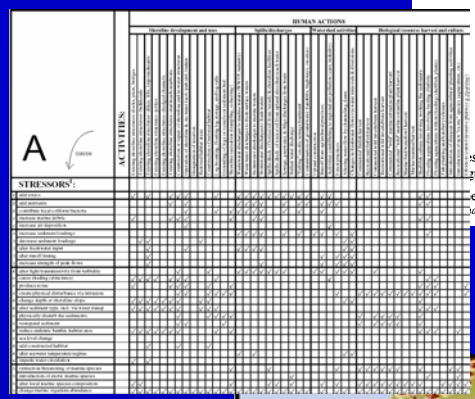
Goals for conceptual models

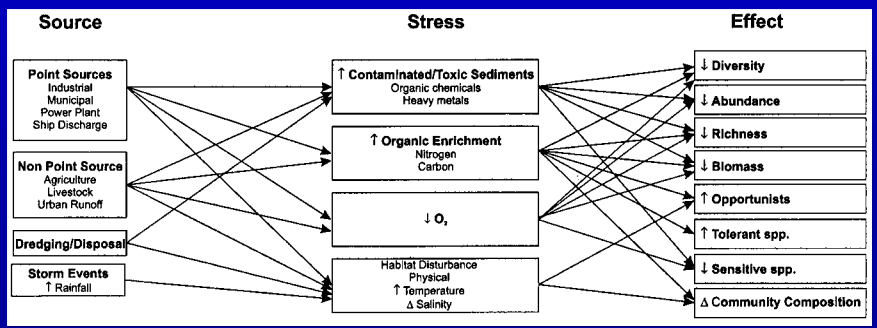
- Formalize current understanding of system processes and dynamics
- Identify linkages of processes, esp. across disciplinary boundaries
- Communicate the bounds and scope of the system of interest
- Clearly identify important interactions and feedbacks
- Illustrate linkages between important processes and vital signs.

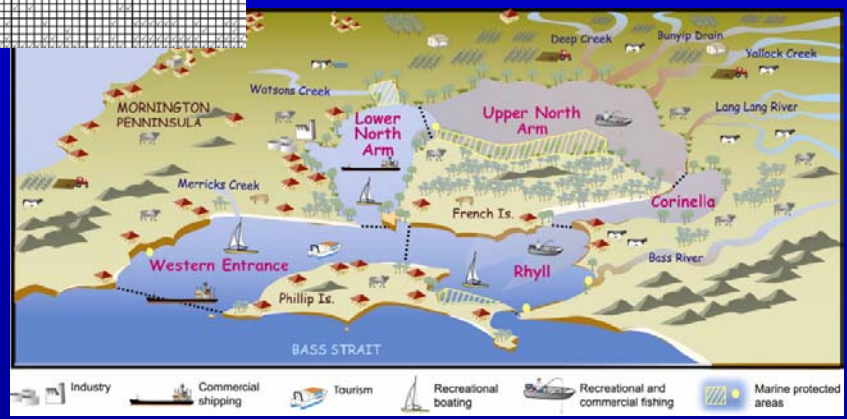
What is a conceptual model, really?

- table of “relationships”?
- picture of system?
- box and arrow diagram?
- narrative?









In the end, most network monitoring plans include

- box and arrow diagrams (one sort or another)
  - eventually, both control (process), and stressor models
- tables with important drivers, responses
- narratives describing models

Models are expressions of hypotheses.
Most models need periodic revision.

A few observations …

- Many model formulations are useful
  - no single model type meets all needs

  "All models are wrong, but some are useful"

- Networks use multiple model structures because it's easier (faster) to construct need-specific models

- Hierarchically structured sets of models have advantages
  - can "begin at the beginning"
  - systematic means to added detail over time
  - coherent set of models with obvious linkages

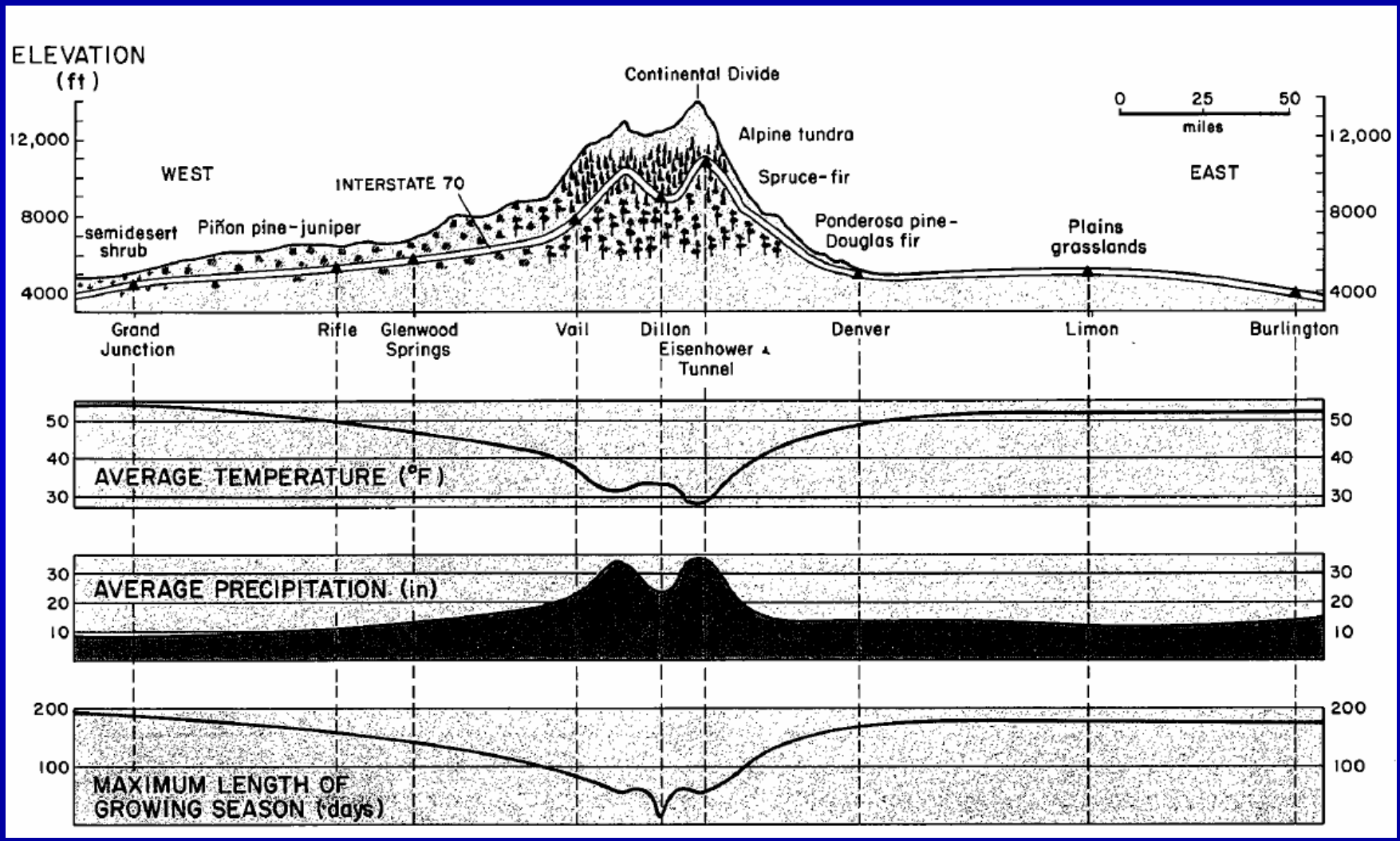
- Craft is important – it takes time to design diagrams

A pragmatic approach to developing useful conceptual models

First steps

1. Define the objectives for the models
2. Identify model bounds
3. Create or adopt a high-level model
    - Provide overarching context
    - Shared reality of system
    - Prevent oversight

A good place to begin … describe the general environs



NCPN modifications to Chapin model

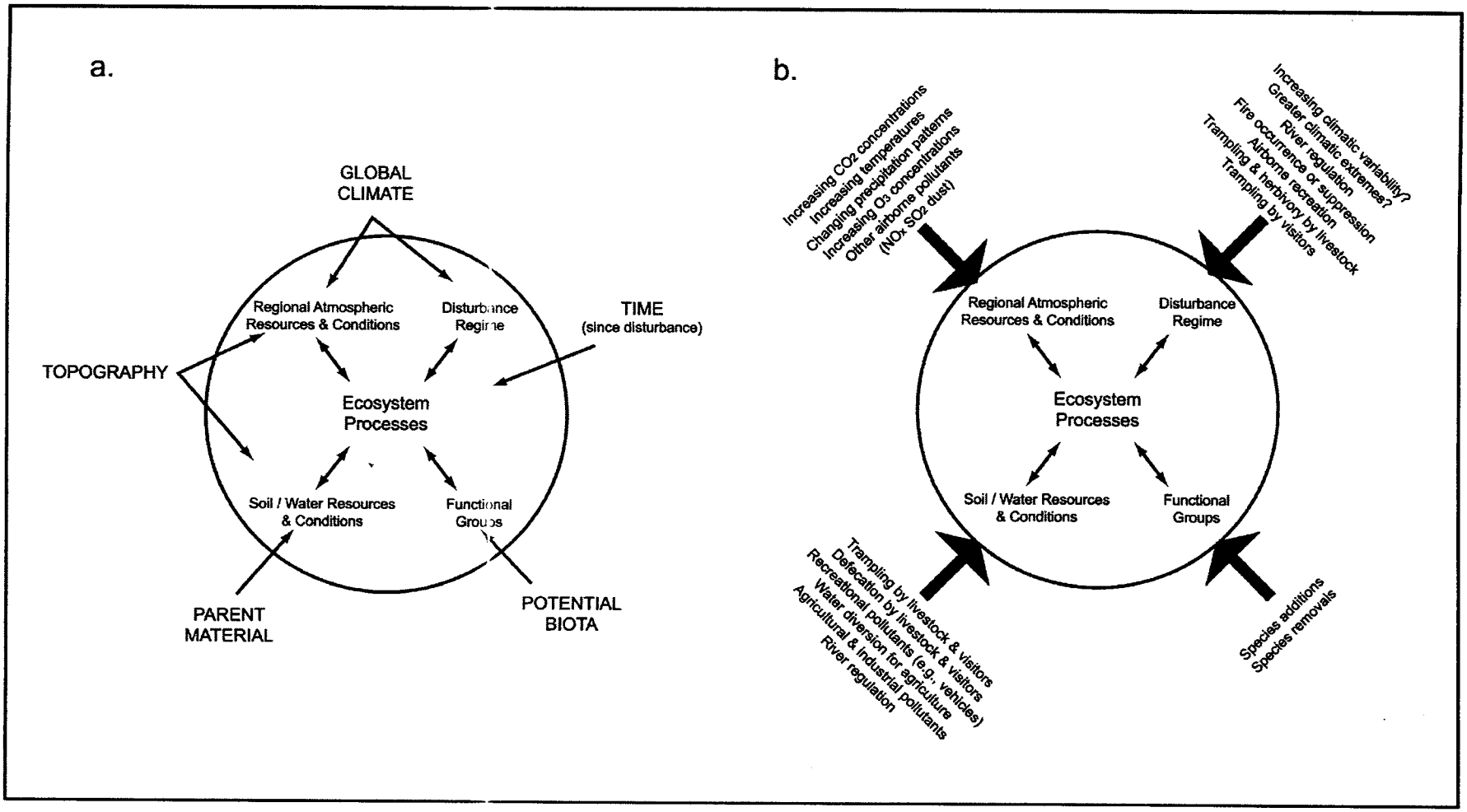


Figure 13. Modified version (a) of the interactive-control model that serves as the general ecosystem model for the NCPN, and (b) the array of stressors affecting NCPN ecosystems arranged in the model in relation to their first-order effects.

SWAN Holistic model

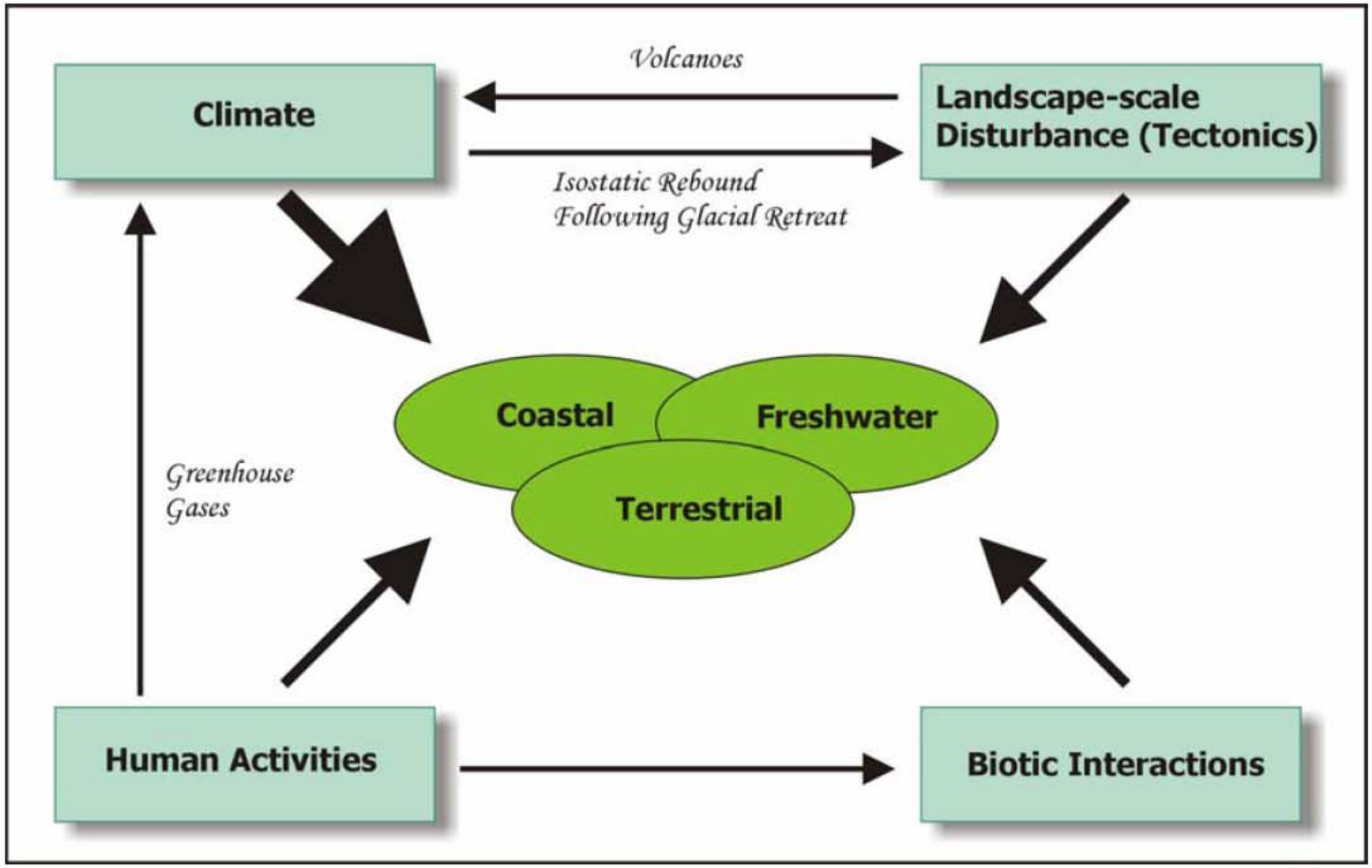


Figure 2-1. Holistic model. Major driving forces shaping park ecosystems are climate, landscape-scale disturbance, biotic interactions, and human activities. The model depicts the close linkages between the primary subsystems (coastal, freshwater, terrestrial) of park ecosystems and feedbacks between the drivers. Drivers can act independently and interactively. For example, volcanic eruptions are a tectonic disturbance that can lower air temperatures.

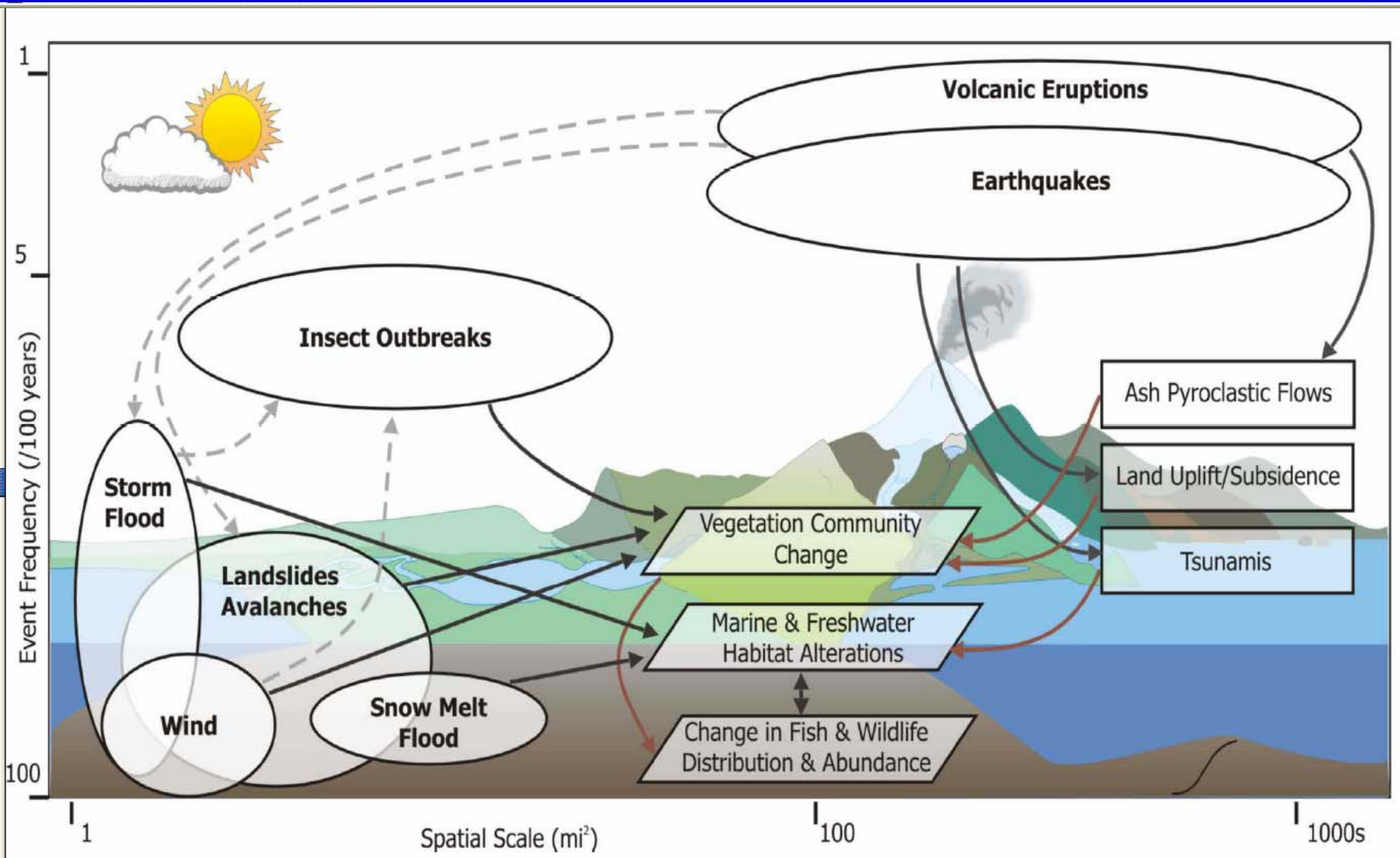


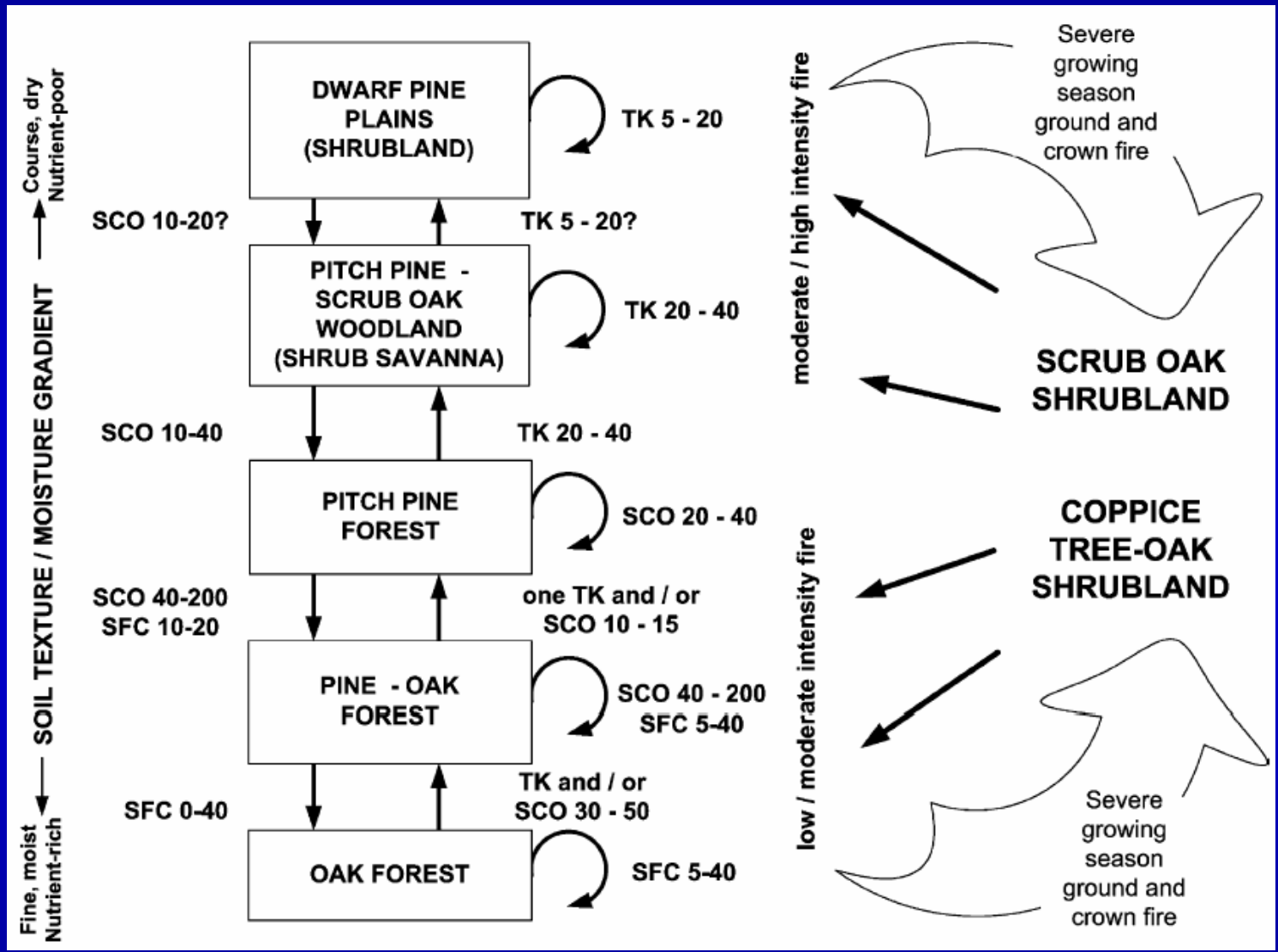
Figure 2-5. Landscape Disturbance Model. Frequency, scale, and consequences of natural disturbances in the Southwest Alaska Network. Large-scale disturbances (volcanic eruptions, earthquakes, tsunamis) and more frequent smaller-scale disturbances (insect outbreaks, floods,

Next, develop models for important ecosystems or subsystems

Systems are place-based! This is how most of us think about the world.

- System dynamics may determine model structure
  - state and transition models
    - arid, semi-arid systems (Mediterranean?)
  - control model
    - causal loop, process, mechanistic model
  - picture model
  - EPA-type stressor model

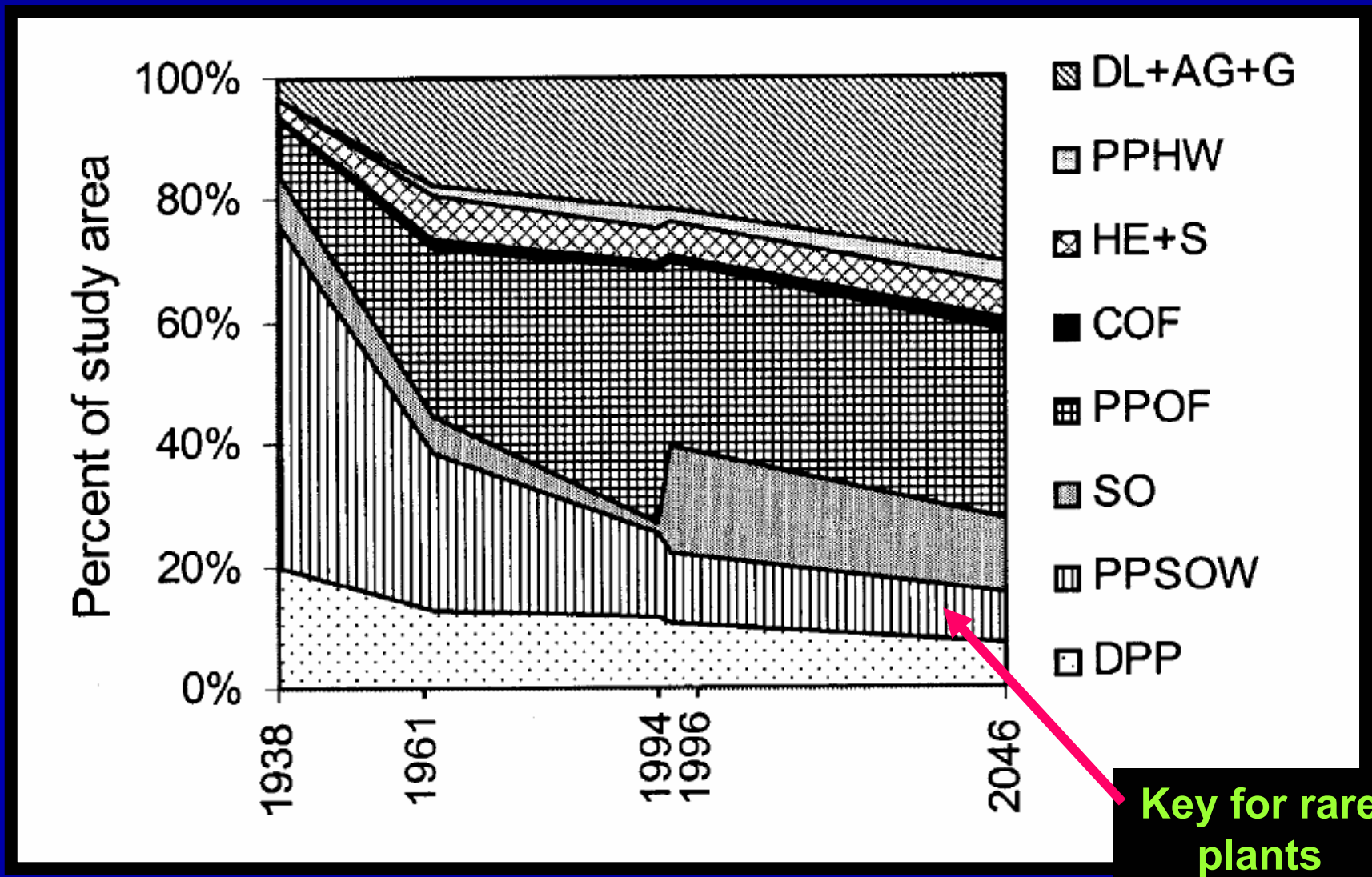
Pine barrens state and transition model



TK = top killing, intense fire; SCO = scorching, moderate fire

Succession model from Jordan et al. 2003

Why are state dynamics important??



Desirable park-like stand
- grassy understory
- ~ 100 trees/ac
- frequent “cool” ground fires
- fires extensive and patchy
- minimal influence by exotics

Overgrazing, fire suppression

Prescribed burning, thinning

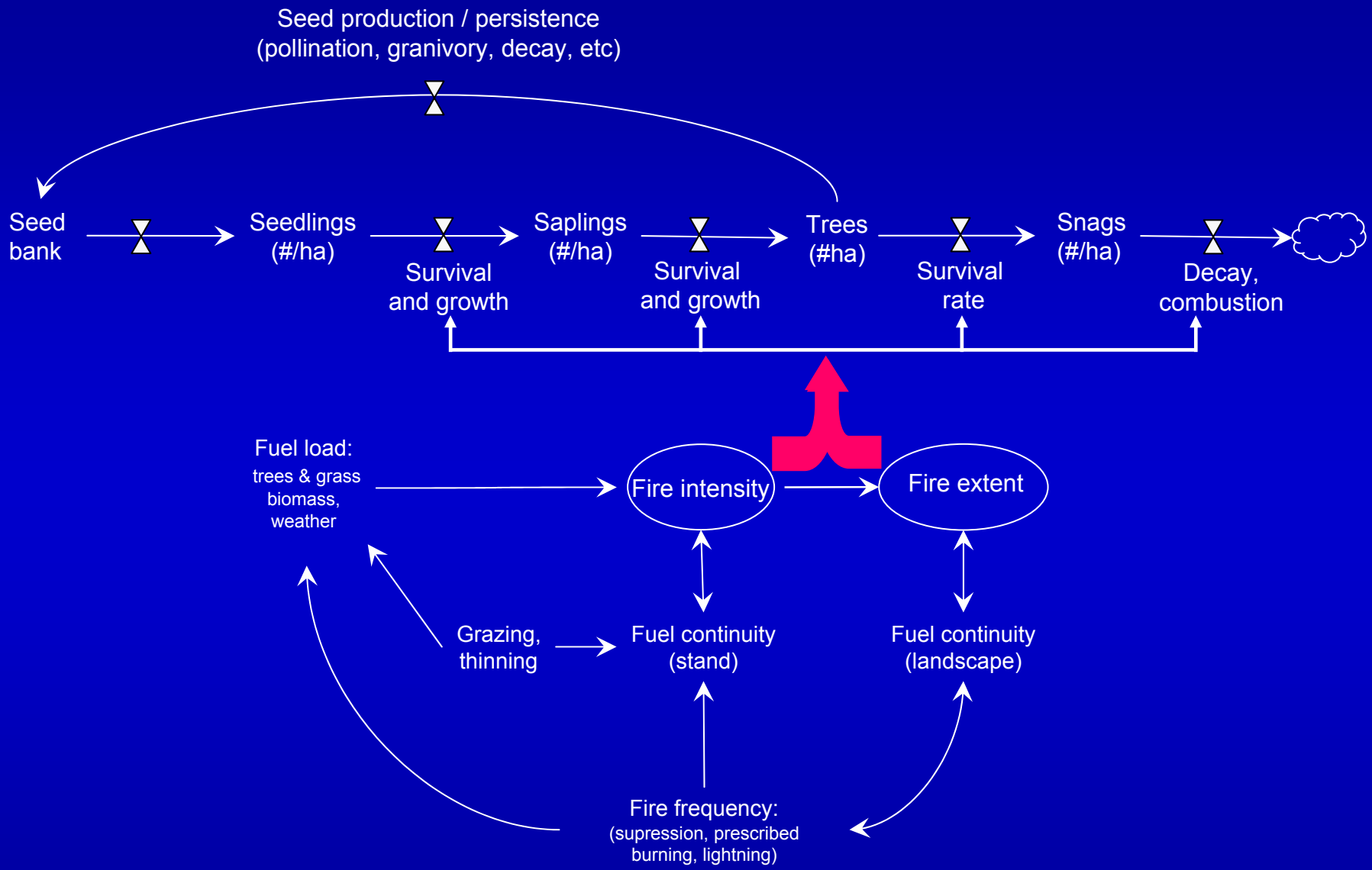
Moderately dense even or mixed-aged stand
- many saplings
- infrequent fire due to supression or non-continuous ground fuel
- fires likely to be intense, extensive, and stand-replacing

Thin and burn?

Intense crown fires

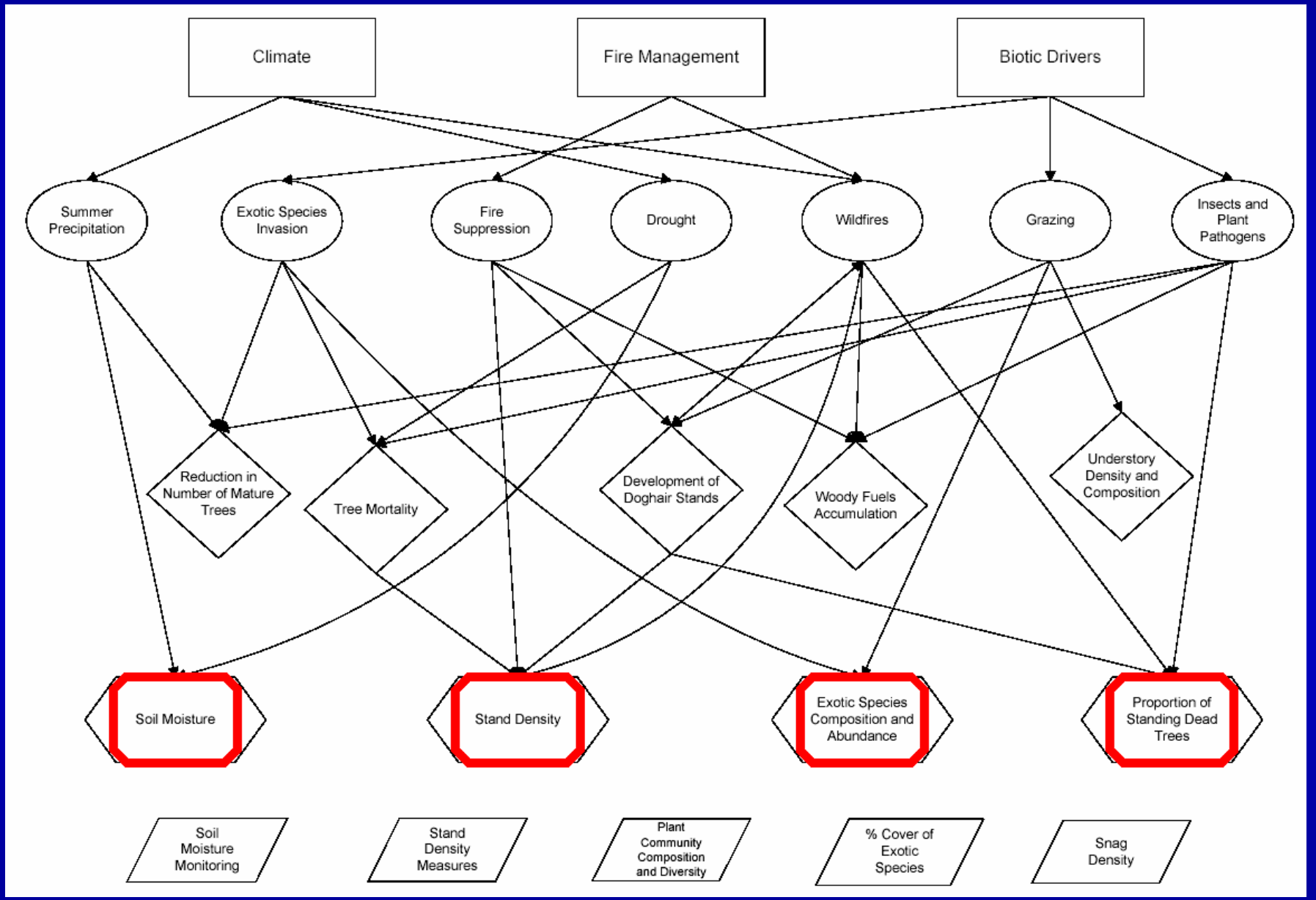
Dense even-aged stand
- stand-replacing fires frequent or infrequent
- understory vegetation sparse
- fuel load large and continuity
- fires very likely to be intense and spatially extensive

Ponderosa pine state and transition model



Ponderosa pine control model

Alternative ponderosa model – GRYN stressor model



Model strengths and weaknesses

Control models

- accurately represent feedbacks and interactions
- usually most realistic structure
- construction yields insights
- often complicated and hard to communicate
- state dynamics may not be apparent

State and transition

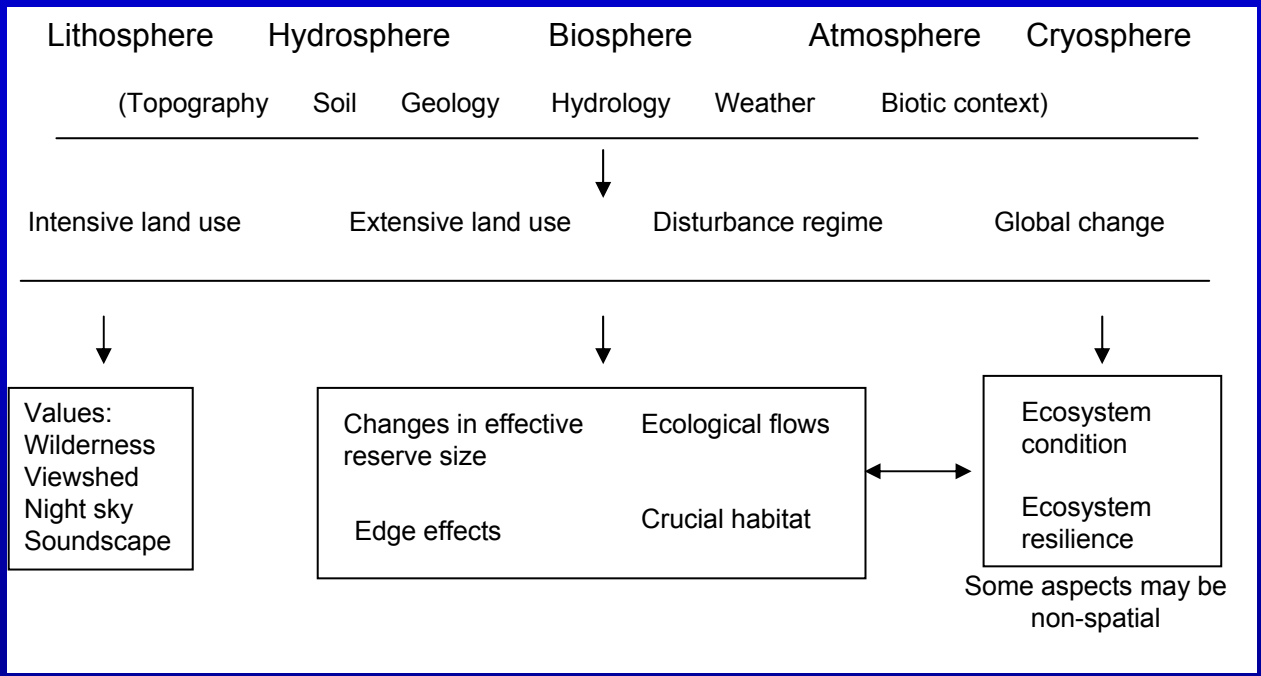
- clear representation of alternative states
- can be simple
- good for communication to most audiences
- generally lack mechanism
- too general to directly link to vital signs

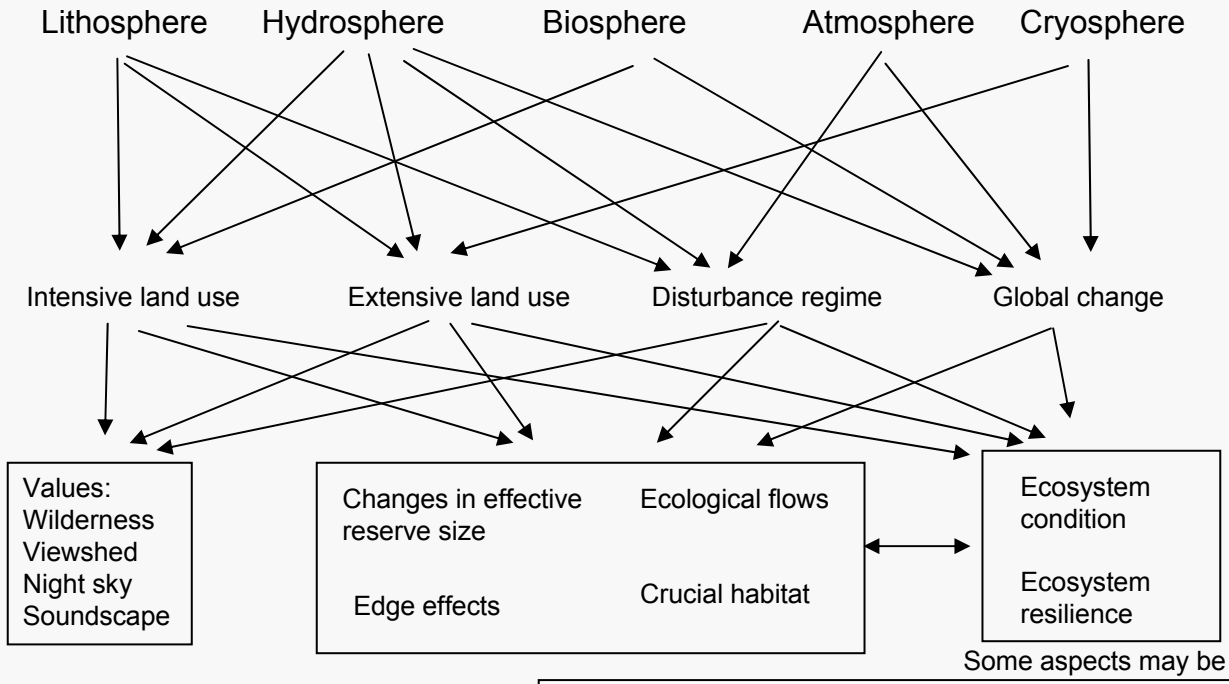
Stressor models

- provide clear link between stressor and VS
- simple and easy to communicate
- no feedbacks
- few or no mechanisms

A bit on the craft …it *does* make a difference!!!

- align boxes, both horizontally and vertically
- use line weights to show significance of linkage
- DO NOT use shaded boxes that will not photocopy
- use few colors and shapes
- aggregate lines when multiple arrows got to the same sets of boxes




Lithosphere
Hydrosphere
Biosphere
Atmosphere
Cryosphere
Intensive land use
Extensive land use
Disturbance regime
Global change
Values:
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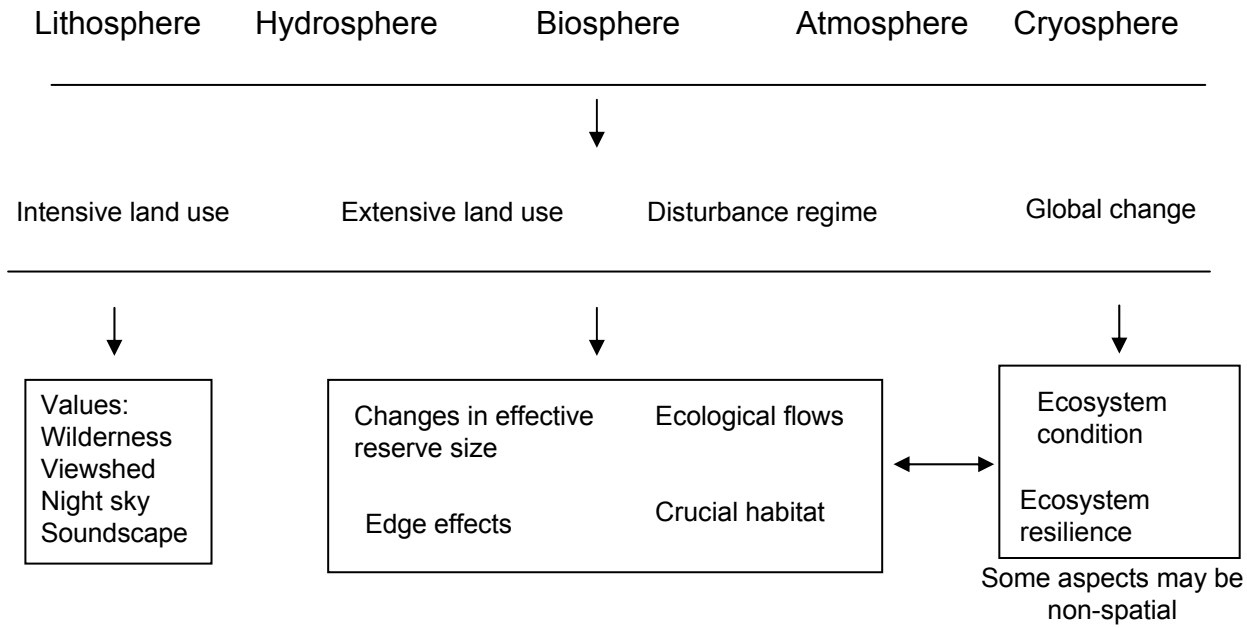
Viewshed
Night sky
Soundscape
Changes in effective reserve size
Ecological flows
Edge effects
Crucial habitat
Ecosystem condition
Ecosystem resilience
Some aspects may be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Some aspects may be non-spatial

Resources for model builders:

I&M Conceptual modelling web page:
www.nature.science.nps.gov/im/monitor/conceptual_models.htm

I&M Conceptual modelling document - http://www.healthywaterways.org/

Maddox et al. 1999 – best single paper

Pugent Sound Conceptual Models

Gulf of Alaska Ecosystem Monitoring (GEM)

Westernport Bay Conceptual Model document (Oct. 2003)

River models (Australia) http://www.healthywaterways.org/

USDA NRCS state and transition models (Brandon Bestelmeyer)

Summary

- Recommendation: adopt a hierarchical set of models
- Create need-specific models
- Use different model structures as appropriate
- Borrow from the many good examples